Space Weather Technical Forecast

Issued on Tuesday, 19 March 2024 at 13:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely (R1-R2 Radio blackouts), slight chance of X-flares (R3 blackouts). Chance of G1 from CME arrivals mainly Day 2 (20 Mar).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity has been Moderate, with the largest flare M6.7, peaking at 18/1919 UTC from AR3615 in the southeast and a further M1 flare also from AR3615 at 19/0231. There are currently seven sunspot regions on the visible disc. The two regions of most interest have both rotated on recently, AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares) and AR3615 in the southeast. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has many smaller spots but is showing a couple of small delta regions. AR3607 has grown in recent hours, developing what appears to be a small and weak delta region in the intermediate portion. AR3616 has also grown recently, after emerging less than 24 hours ago, having now developed rudimentary penumbra and perhaps also a delta spot. The remaining regions currently appear stable.

No Earth directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds as observed by ACE at L1 were indicative of ambient conditions, until a CME arrival around 18/1940 UTC. Wind speeds have been at ambient levels throughout, but jumped from near 300 km/s to around 360 km/s after the CME arrival, where they has remained since. Density was around average for most of the period. Interplanetary Magnetic Field, Bt, was weak, but jumped to moderate briefly with the CME arrival, peaking at 11nT. The north-south component, Bz, varied weakly at first, but became moderately southward directed for a time after the CME arrival, before returning to varying weakly. Phi angle was mainly positive (away from the Sun), switching to mostly negative after the CME arrived, before returning to positive again recently. Geomagnetic activity was Quiet to Unsettled (Kp0-3).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was initially slightly elevated after the S1 enhancement on 15-16 Mar, with a peak of 1.5pfu at 18/1245 UTC, before falling back to background levels through the period. High energy electron flux (greater than 2MeV) observed at GOES16 was mostly at background levels, but just reached moderate levels at the diurnal maximum. The observed 24-hour fluence was below the Active threshold, with the value at 19/0000UTC 8.74e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is now considered likely with a slight chance of becoming High with any isolated X-flares, mostly due to AR3614 and AR3615, but with some growth in other regions suggesting these are worth watching too.

Solar Wind / Geomagnetic Activity: A recent CME arrival has been observed at L1, and there is still the possibility of further glancing CME interaction through Day 1 (19 Mar), although this becomes less likely through the day. A further arrival is then expected on Day 2 (20 Mar), probably from the slower of the two CMEs from the filament eruption on 17 Mar, but perhaps also a glancing impact from the slightly faster and further south of these CMEs. Ongoing effects

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are possible on Day 3 (21 Mar), before easing. Aside from the CMEs, no other sources of notable enhancement to solar winds are forecast.

Geomagnetic activity is expected to be Unsettled to Active, with a chance of G1/Minor Storm conditions, perhaps on Day 1 with the current CME enhancement but more likely on Day 2 with the filament eruption CME from the 17 March. Effects are then likely to decline through Day 3, becoming largely Quiet by Day 4 (22 Mar) in the absence of further CMEs.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux at GOES18 is expected to continuing gradually easing to background levels, with a slight chance of further enhancements. This risk increases slightly later in the period as AR3614 and AR3615 rotate towards centre disc. High energy electron flux (greater than 2MeV) is expected to persist at mainly background levels with the associated 24 hour fluence remaining below the Active threshold.

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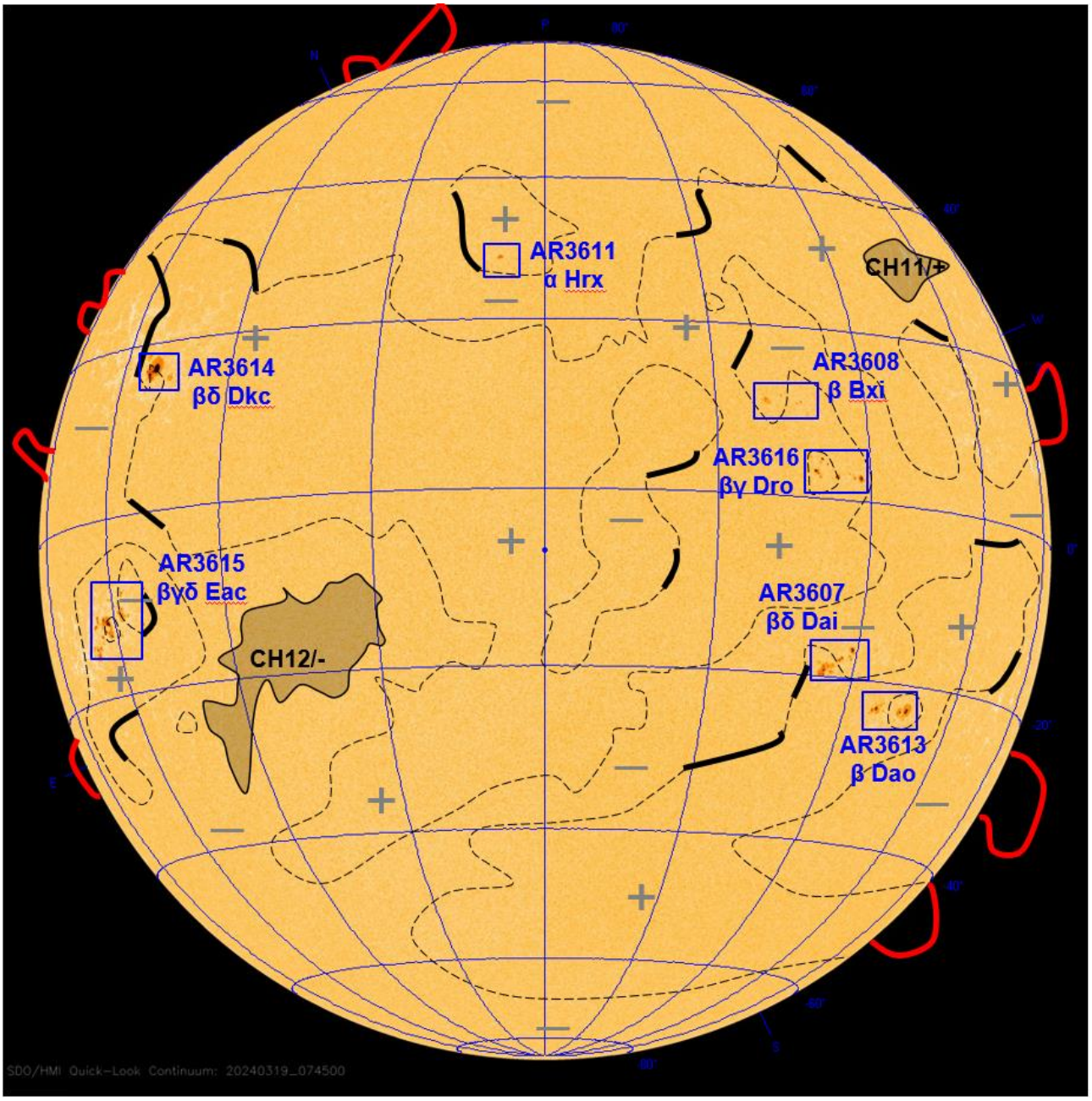
Figure 1. Solar Analysis Valid 19/0800.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is the possibility of a glancing CME interaction through Day 1 (19 Mar), although this becomes less likely through the day.

A more notable CME was observed from a filament eruption from the southeast disc, occurring near AR3613 at around 17/0230 UTC. This is a complex eruption, splitting into two separate CMEs. The first one went to the southeast, and is faster, narrower but brighter on imagery, likely giving a glancing impact during the second half of Day 2 (20 Mar). The second to the southwest is fainter, slower and wider, and consequently more likely to be observed arriving at Earth and is also expected during the second half of Day 2, with ongoing effects possible on Day 3 (21 Mar), before easing.

Aside from the CMEs, no other sources of notable enhancement to solar winds are forecast, with CH11/+ too far north and unlikely to bring any notable influence.

Geomagnetic activity is expected to be Unsettled to Active, with a chance of G1/Minor Storm conditions, perhaps on Day 1 with the current CME enhancement but more likely on Day 2 with the filament eruption CME from the 17 March. Effects are then likely to decline through Day 3, becoming largely Quiet by Day 4 (22 Mar) in the absence of further CMEs.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	40	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1035	Partial	Filament	SW	505 km/s	20/2000UTC	Limited shock expected. Moderate confidence. Perhaps preceded by glancing blow.

Figure 2: MOSWOC Enlil and ensemble, showing the main CME hit likely on 20 March, but with the potential for other glancing blows through the period.

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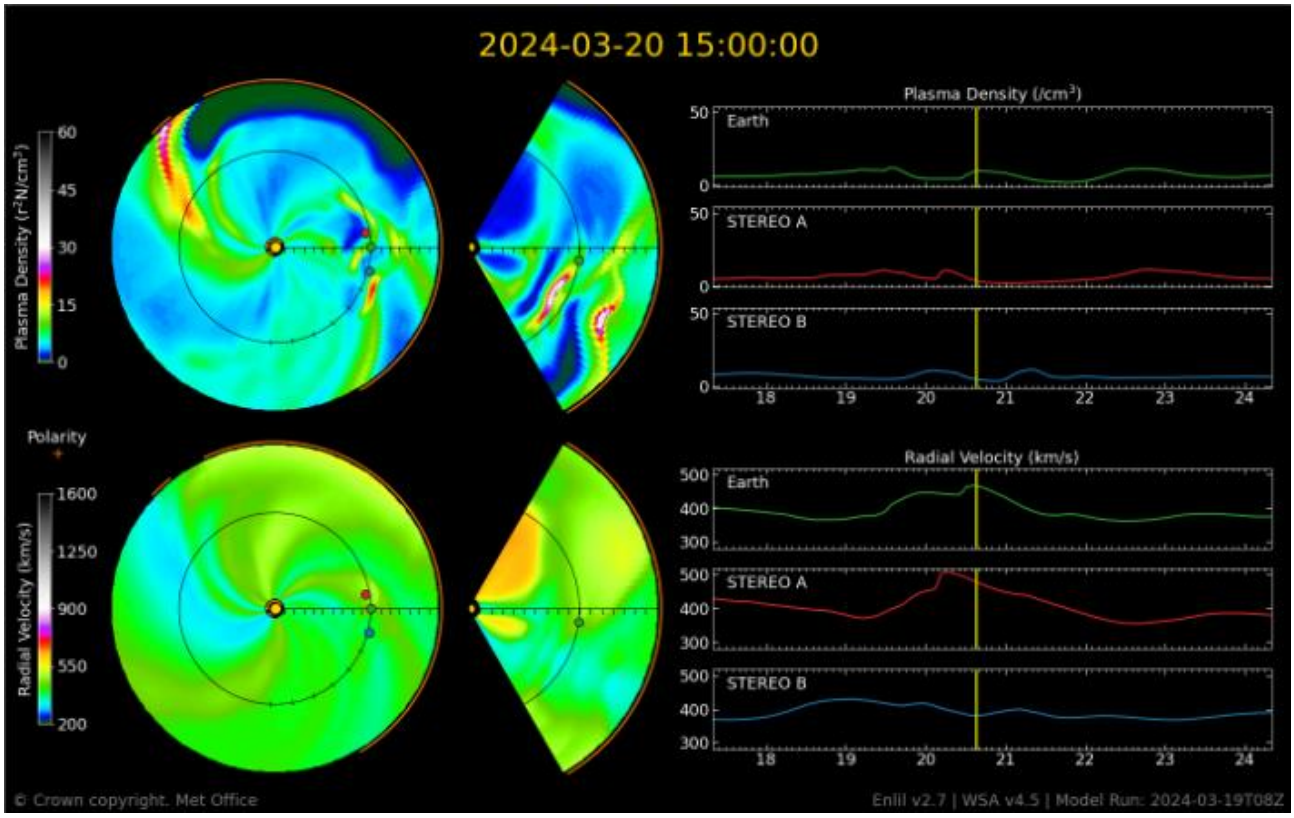

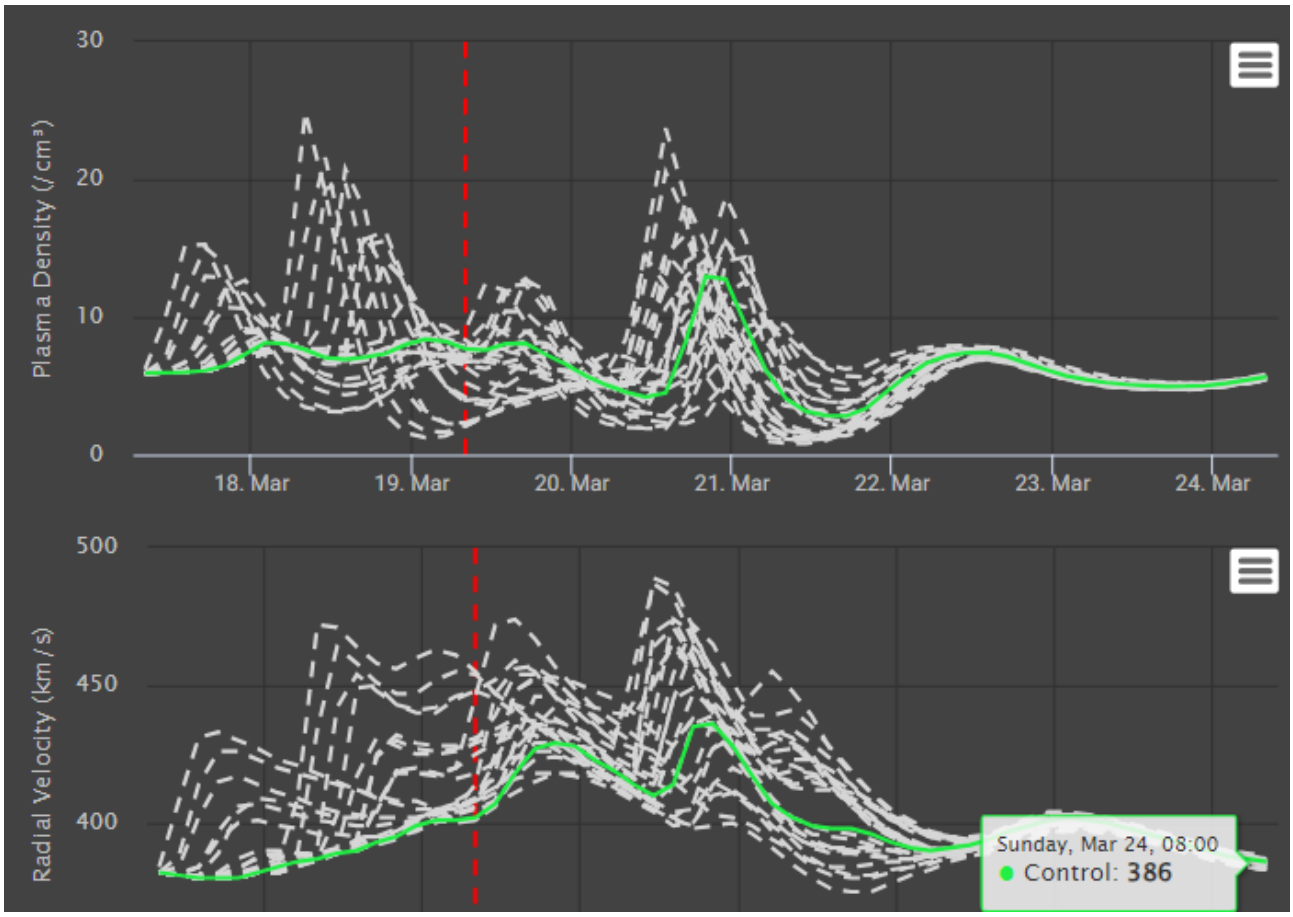

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Radio Blackouts - X-Ray Flares:

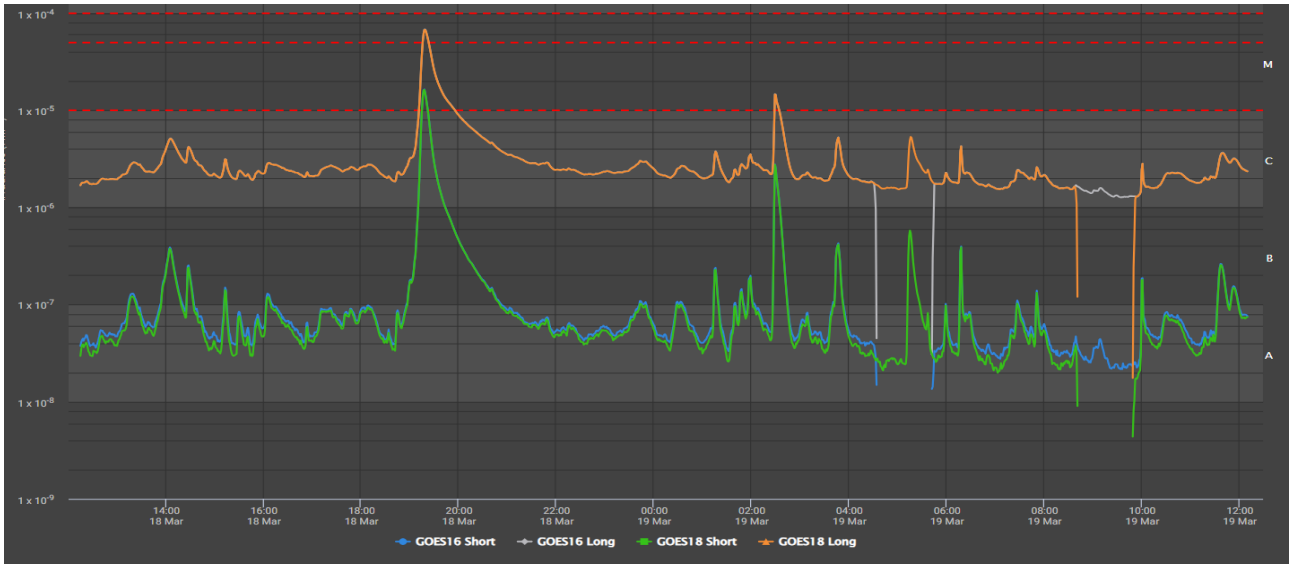
Activity has been Moderate, with the largest flare M6.7, peaking at 18/1919 UTC from AR3615 in the southeast and a further M1 flare also from AR3615 at 19/0231.

There are currently seven sunspot regions on the visible disc. The two regions of most interest have both rotated on recently, AR3614 in the northeast (likely ex-3590 from the previous rotation which gave three X-flares including an X6.3, the largest of this solar cycle so far) and AR3615 in the southeast. AR3614 has a large main spot with a clear delta configuration, whereas AR3615 has many smaller spots and is showing a couple of small delta regions. AR3607 has grown in recent hours, developing what appears to be a small and weak delta region in the intermediate portion. AR3616 has also grown recently, after emerging less than 24 hours ago, having now developed rudimentary penumbra and perhaps also a delta spot. The remaining regions currently appear stable.

Moderate activity is now considered likely with a slight chance of becoming High with any isolated X-flares, mostly due to AR3614 and AR3615, but with some growth in other regions suggesting these are worth watching too.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: X-ray flux at GOES16 and 18, showing three M-flares in the last 24 hours, all from different locations.



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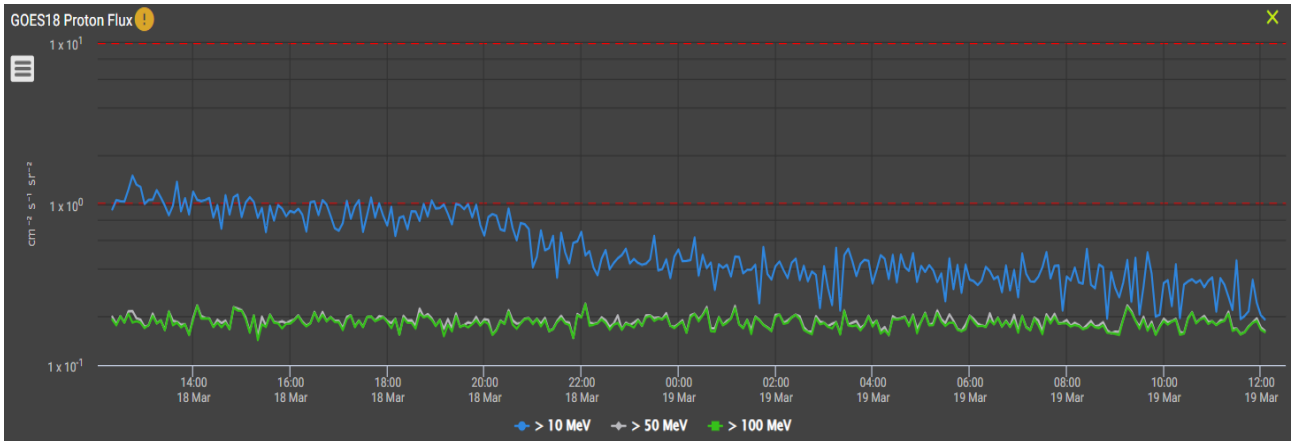
Solar Radiation Storms - (High Energy Protons):

High energy proton flux, as observed by GOES-18 has slowly fallen to background levels after the recent enhancement on 15-16 Mar. Flux is expected to remain at background over the next couple of days, with further enhancements unlikely on Days 1 and 2 (19-20 Mar). As AR3614 and AR3615 rotate towards centre disc later in the period, they move into a slightly better location for proton events to reach Earth and the probability of reaching S1 rises a little.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Proton flux at GOES18, showing 10MeV protons slightly above background levels but well below S1.



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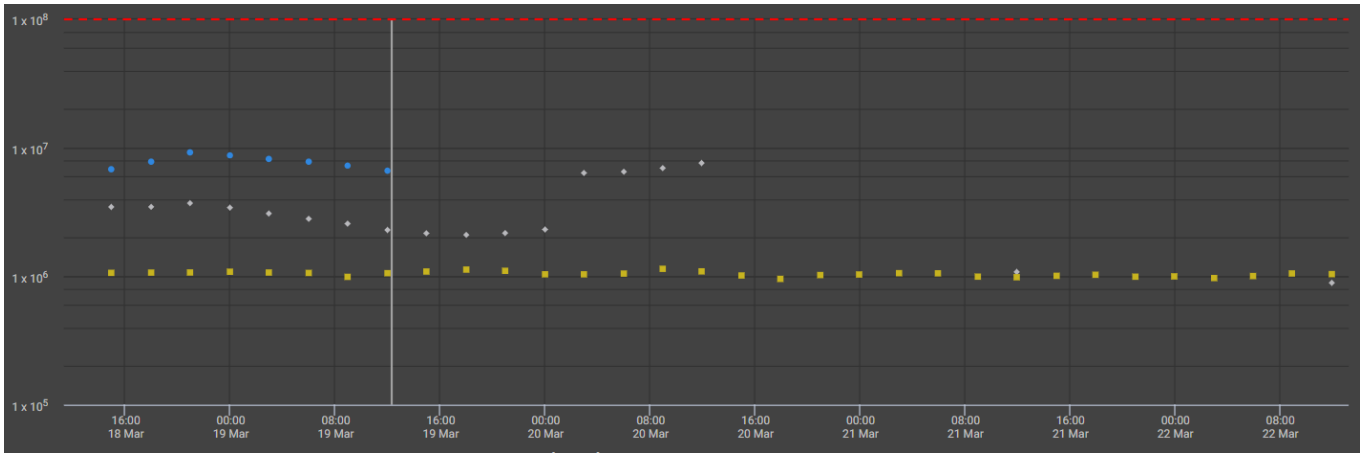
High Energy Electrons Event (≥ 2MeV):

GOES-16 electron flux is expected to remain at mostly background levels, with no significant sources of enhancement expected. Current CME impacts may lead to brief moderate flux, however the slow wind speeds mean this is unlikely. A further likely CME arrival is expected on Day 2 (20 Mar) and into Day 3 (21 Mar), however this is also likely to only have a minimal impact on the observed electron flux.

The associated 24 fluence is expected to remain below the Active threshold, with MOSWOC REFM in agreement and providing good guidance.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	1	1
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REFM showing fluence remaining below Active through the next few days, which seems like good guidance.



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